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Flood hazard assessment using Geographic Information Systems of wadi El-dukhan, western desert, Sohag Governorate, Egypt

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ABSTRACT

The study aims to investigate Wadi Dukhan in the Western Desert in Sohag Governorate, which has an area of 50 square kilometers in terms of its nature and the rainfall that falls on it, in order to identify the places at risk of flooding. This study employed grid-based Curve Number (CN) method through the GIS drainage analysis operating on digital elevation models (DEM) to estimate surface runoff depth in Wadi El-Dukhan catchment, Sohag, Egypt. In the SCS (Soil Conservation Service) based hydrologic modelling system, the CN plays a significant role in determining runoff. It takes into account factors like slope, vegetation cover, and catchment area. The curve number values from NRCS standard tables were assigned to the intersected hydrologic soil groups and land use maps to generate CN values map. Effect of slope on CN values and runoff depth was determined. Topographic, soil and land use maps data were used in preprocessing in the Arc GIS 9.3 and Arc Hydro 9 for computing Hydrologic parameters. To estimate the curve number from which the daily runoff was approximated, GIS software was used for data generation, storage, manipulation, and integration. Calculations were made for surface storage volume and initial abstraction.

It was found that during the last six years (2010-2016), Wadi Dukhan rained six times, three of these events were during 2012, while the rest of the times were once a year. The rain at 2012 was the highest (1 mm / hour). According to the geological assessment of the area it has been found that there are two main areas. The first is made of hardened limestone, which reduces water intrusion and increases runoff. The hydrological soil group 'C' was chosen for this area, so the corresponding CN was equal to 86. This value increases with increasing slope; it was in some places up to 86. The second category consisted of Quaternary flood sediments, which consist of grains sand and gravel, causing a decrease in runoff rates and an increase in the possibility of water infiltration into groundwater; this class is classified as 'A' hydrologic soil group type. The corresponding CN value was 63. This value also differed according to the slope difference in this region. Also, in the present study Wadi Dukhan was divided into 29 subcatchments. It was found that a very large area of the region has a high CN value of 86, which means that the study area is in a poor hydrological condition that makes the water run-off high. This is due to the type of soil and poor vegetation.

Keywords: Rainfall, Runoff, GIS, SCS-CN method, Curve Number, Wadi El-Dukhan

INTRODUCTION

Floods are considered as one of the most common disasters and probably the most devastating (Baoyin and Hailin, 2009). Flood analysis and flood risk prediction currently increasingly use geographic information systems (GIS) and digital elevation models (DEM)

(Yang et al., 2002). Over the years the flood events have greatly increased. One of the factors responsible for this is the population pressure on the urban areas which not only impacts the urbanization but results in tremendous socioeconomics losses (Yahya *et al*., 2010). Surface runoff, or overland flow, occurs when the soil is no longer capable of absorbing rainwater, or removing it via the processes of transpiration, infiltration, and sub-surface runoff.

The interactions between numerous geological and morphological basin parameters, such as rock kinds, elevation, slope, sediment transport, and flood plain area, make flood occurrences complex. Moreover, hydrological processes including precipitation, runoff, evaporation, and the storage of surface and groundwater can affect floods (Farquharson *et al*., 1992; Flerchinger and Cooly, 2000; Şen, 2004; Nouh, 2006).

In Egypt, several flash flood events occurred as shown in Table (1).

Table 1: Flash flood main events in Egypt (Abu El-Magd, 2008).

Date	Effected area	Recorded damages
Feb. 2015	Sinai, Red Sea region	Road damages
Mar. and May 2014	Taba, Sohag, Aswan, KomOmbo	Dam failure at Sohag road damages
2013	South Sinai	2 death, road damages
2012	Wadi Dahab, Catherine area	Dam failure, destroyed houses
Jan. 2010	Along Red Sea Coast, Aswan, Sinai	12 death, houses and road damages
Ct. 2004	WadiWatr	200 deaths, destroy roads, demolished houses, damaged vehicles
May 1997	Safaga, El-Qusier	
Nov. 1994	Hurghada, MarsaAlam	
Sep. and Nov. 1994	Dahab, Sohag, Qena, Safaga, El-Qusier	Destroyed houses
Mar. and Aug. 1991	MarsaAlam, WadiAwag	5 deaths
Oct. 1990	Wadi El-Gemal, Marsa Alam	
Jan. 1988	Wadi Sudr	1 death, road damage
Oct. 1987	South Sinai	23 deaths, demolished houses
May and Oct. 1979	Aswan, KomOmbo, Idfu, Assiut, Marsa Alam, El-Qusier	20 deaths, road damages
Feb. 1975	Wadi El-Arish	road damages
1972	Giza	

The Study Area

Wadi El-Dukhan is located in the middle part of the Western Desert, western of Sohag Governorate, beside Gerga City. It is lying between Latitudes 26 ° 10' and 26° 15' N and Longitudes 31° 45' and 31° 50' E as shown in Figure (1). The total area of the wadi catchment is 50 km^2. The study area is overlooked by the Lower Eocene limestone plateau. It is lying between Wadi W. El-Mahasnah and Wadi W. Bayt Dawod. The cultivable land extends between the River Nile and the scarp cliffs that bound its valley on eastern side.

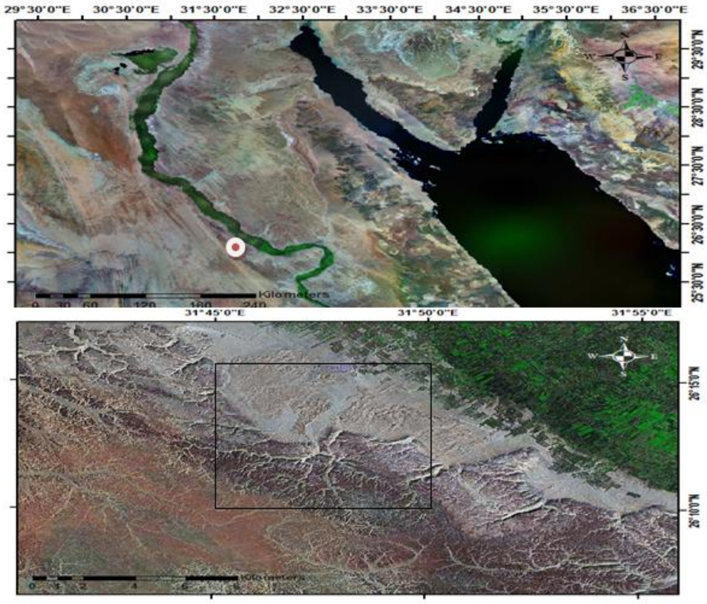


Fig. 1. Site map of Wadi El-Dukhan showing regional satellite image of Egypt with study area in red box (top), and detailed satellite image for the study area (bottom).

The frequency of the floods during the period 1950 – 1994 in Sohag area was given in Table (2) after Saleh (2000).

Table 2: Frequency of the floods and the average periods between them in Sohag area (Saleh, 2000).

Area	Flood date	Number	Period range
Sohag	1950, 1966, 1967, 1968, 1969, 1975, 1980, 1985, 1994	11	2 - 9 years

A wadi is a stream that only occasionally runs at full capacity, typically during and after a rainfall that generates runoff. Ephemeral streams in arid areas can be described using it (Saber, 2010). Wadi El-Dukhan, as other arid areas has distinctive hydrological features with limited water resources. The hydrological regime is characterized by high variability of temporal and spatial rain fall distributions, flashfloods, absence of base flow, and high rates of evapotranspiration (Abushandi, 2011).

The present work aims to evaluate the flash flood hazards and their environmental impacts in Wadi El-Dukhan area using Geographic Information Systems.

METHODOLOGY

Studying flash flood in watershed is determined by collecting and analyzing meteorological, topographical, and morphological data, however, in many arid and semi-arid regions data is usually limited and incomplete and watersheds are mostly ungauged. A great challenge is to select the proper runoff model which suits the available data. This problem has been faced by several researchers who have studied and analyzed watershed in arid regions to developed appropriate rainfall-runoff models (Cirilo *et al*., 2020).

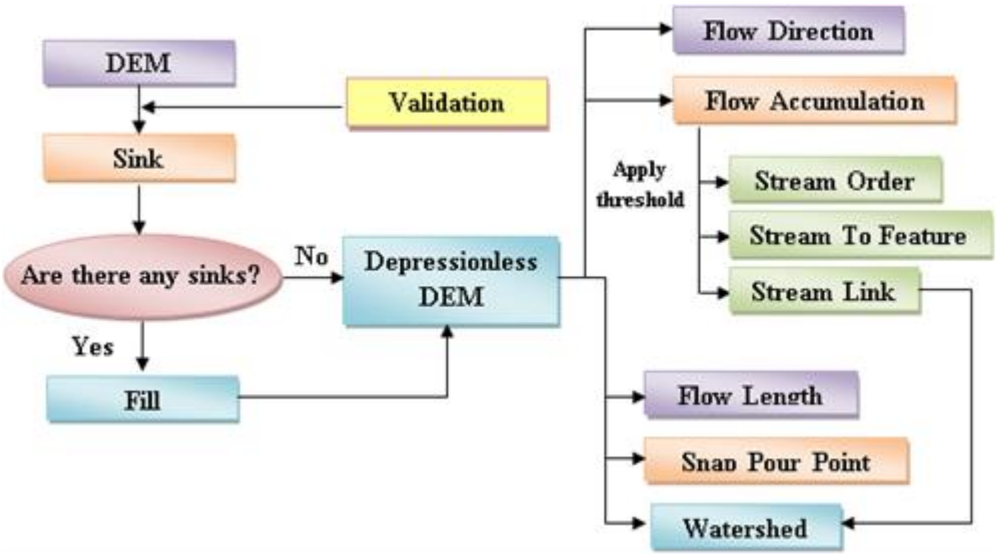
1. Digital Elevation Models (DEMs) for raw data

Digital elevation model (DEM) data consist of a sampled array of regularly spaced elevation values referenced horizontally either to a Universal Transverse Mercator (UTM) projection or to a geographic coordinate system (Zein, 2021). The grid cells are spaced at regular intervals along south to north profiles that are ordered from west to east (USGS, 1998; SRTM, 2015).

2. Geographic Information System

GIS is an effective tool for spatial analysis and comprehending the peculiarities of watersheds. It can calculate the watershed properties (watershed areas, stream network, slope, etc.). It can also identify and delineate areas near to the stream channel, that most likely to be affected by flashfloods. ArcGIS version 10.0 software was used for managing and generation of different layers and maps. Arc Hydro, which is integrated in ArcGIS, was also used for the successive calculations for the delineation and calculation processes of the watershed basins.

The Microsoft Excel was used for mathematical calculations. So the watershed analysis for Wadi El-Dukhan was performed with GIS starting with delineation of Watershed Basin of Wadi El-Dukhan and this watershed is divided into multiple subwatersheds as follows:



3. Runoff estimation

There is a threshold that must be exceeded before runoff begins, according on analysis of storm event rainfall and runoff records. The storm must satisfy interception, depression storage, and infiltration volume before the onset of runoff. The rainfall required to satisfy the above volumes is termed initial abstraction. Additional losses will occur as infiltration after runoff begins, whereas accumulated infiltration increases with rainfall up to some maximum retention amount. Runoff also increases with rainfall (Shadeed, 2010; Xianzhao and Jiazhu, 2008).

In this study the Soil Conservation Service – Curve Number (SCS-CN) model, which fully considers physiographic heterogeneity (e.g. topography, soil and land use) was used to simulate the rainfall-runoff relationship of watershed. The SCS-CN method is based on the water balance equation and two hypothetical equations such as the proportional equality and linear relationship between the initial abstraction and potential maximum retention (Mishra and Singh, 2003; Elewa *et. al*., 2012).The first hypothesis equates the total rainfall (P) to the actual amount of direct surface runoff (Q), and the initial abstraction (I_a). The second hypothesis shows relationships among Ia, the amount of the potential maximum retention (S), P and Q. Thus, the CN method consists of the following equations (Mishra and Singh, 2003); The water balance equation is expressed as

$$Q = P - (I_a + S) \quad \text{……………………..(1)}$$

where Q is runoff depth or excess rainfall in (mm), P is the depth of rainfall in (mm), S is the maximum potential retention after the beginning of runoff (the ability of the soil to absorb or retain moisture) in (mm), and I_a is the initial abstraction before the beginning of runoff (This can include water stored by surface depressions and water intercepted by vegetation, evaporation, and infiltration) in (mm).

Runoff in subbasins occurs after rainfall exceeds an initial abstraction (I_a) value. Rainfall excess (P) is related to the effective potential retention value (S) as given in equation (3). The optimum values of λ were obtained in the least squares fitting procedure were around 0.05 for most experimental plots which were observed by Hawkins *et al.* (2002). Therefore, it was decided to set it as 0.05 in this study. The initial abstraction is a function of potential maximum retention S. S is a function of curve number CN which can be evaluated based on the land use and soil types as given in equations (2) and (4).

$$Q = \frac{(P - I_a)^2}{P - (I_a + S)} \quad \text{……………… (2)}$$

$$I_a = \lambda S \quad \text{……………… (3)}$$

$$CN = \frac{25400}{254 + S} \quad \text{……………… (4)}$$

where Q is runoff depth or excess rainfall in (mm), P is the depth of rainfall in (mm), S is the maximum potential retention after the beginning of runoff (mm), and I_a is the initial abstraction before the beginning of runoff (mm), λ is a dimensionless parameter varying from 0 to 1, and CN is the curve number of hydrologic soil cover complex, which is a function of soil type, land cover and antecedent moisture condition (AMC) (Kumar *et al*., 2010).

By substituting the value of weighted CN in equation (4), the retention capacity Scan be calculated. By involving the calculated value of S in Eq. (3), the initial abstraction can also be calculated using appropriate values for λ as discussed above. The direct runoff Q can then be calculated based on the SCS-CN method using Eq. (2).

The CN for a drainage basin is estimated using a combination of land use, land cover, soil type, Hydrologic soil groups and antecedent soil moisture condition (AMC). CN values range from 0 to 100 (Xianzhao and Jiazhu, 2008). There are four hydrologic soil groups: (A, B, C & D) depict the potential runoff based on texture, bulk density, clay mineralogy, soil structure, and organic matter. Group A hydrologic soil group has a low potential for runoff. This group is composed of nearly 90 % sand and only 10 % clay. Loamy sand, sandy loam and/or loam if aggregated are categorized as group A. Group B hydrologic soil group have moderately low runoff potential. Group B is composed of 10% to 20% clay and 50% to 90% sand, loamy sand, sandy loam, and/or loam. Group C hydrologic soil groups have moderate runoff. The amount of clay is 20% to 40% and the sand is 50%. Group D hydrologic soil group has a high potential for runoff. Water movement through the soil is slowed more than the previous hydrologic soil groups. Group D has more than 40% clay and less than 40% sand, loamy sand, sandy loam, and/or sand (Soil Survey Division Staff, 1993; Panda, 2011; Sumarauw, 2013). Antecedent Moisture Condition (AMC) is an indicator of watershed wetness and availability of soil moisture storage prior to a storm, and can have a significant effect on runoff volume. Three AMCs were defined as dry, moderate and wet, and denoted as AMC I, AMC II, and AMC III, respectively.

RESULTS AND DISCUSSION

1. Geomorphology and Geologic setting

1.1 Geomorphological Features

Following these plateaus inward, there are low desert land areas followed by the agricultural areas surrounding the River Nile. The limestone plateau that borders the study area from the east and west is divided by numerous wadis that primarily run in the east-west orientations. The main geomorphological features found in the study area include four main units (Fig. 2) and each unit has its own shape, pattern, and relief.

a- The Nile flood plains

The agricultural lands east and west of the River Nile that makes up the Nile flood plains are what are meant by that term. They also contain mud and silt deposits that have been broken up by irrigation canals and drains at the top surface. The elevation of the flood plains, which ranges from 55 to 65 m above mean sea level, is virtually flat and slopes from south to north. Nearer to the eastern edge of its valley, the River Nile flows from south to north. In general, the farmed fields east of the flood plain are substantially narrower than those on the western bank of the river. These deposits, generally belongs to the Holocene. Abd El-Kireem (1972) stated that the recent deposits in the eastern side of Sohag area are essentially the alluvium and cover the floor of the Nile Valley. They are mainly deposited by floodwater during recent times and comprise unconsolidated sediments and gravels present nearly everywhere. Mostafa (1979) described the recent deposits in the area of northeast Sohag as alluvial deposits, composed of clays and silts with sandstone intercalations. Ahmed (1980) mentioned that recent deposits exposed in the area west and southwest of Sohag and are covered by the River Nile's flat alluvial plain. They are made of mud and silt, which floodwaters from more recent geological periods have deposited.

b. The low land desert areas

In the elevated areas between the agricultural lands and the Limestone Plateau's margins, low-lying desert regions can be found on both sides of the Nile Valley. These regions, which are represented by a sequence of terraces with various heights, are the original alluvial plains. These low-lying deserts are situated between 70 and 160 meters above mean sea level. Abd El-Kireem (1972) studied the stratigraphic section of the River Terraces exposed in the area east of Sohag. He concluded that the deposits of these terraces belong to Pleistocene and Plio-Pleistocene. He divided the Pleistocene terraces in the Issawia-Kola plain at the area east and southeast of Sohag into two groups according to their elevation and the percentage of deterital constituents. The first one of these terraces lies 15-20 feet above the cultivated land and is composed of gravels, limestone, and flint fragments of very small size in a sand and clay matrix. The second one of Pleistocene terraces lies 100 feet above the cultivated land. It is formed of large blocks of porous limestone (travertine), gravels, sands which are embedded in a ferruginous sandy and clayey matrix.

c. The Limestone plateau

The limestone plateaus of the Sohag district are a significant portion of the Eocene Limestone plateau of the Eastern and Western Deserts of Egypt and they border the low land desert from the west and the east. It rises between 200 and 300 meters above sea level and often gets smaller toward the north. Due to the impact of constructions and weathering, the surface of this plateau on either side of the river is uneven**.**

d. The transverse channels

The surfaces of the limestone plateau are dissected by dry drainage wades that filled by sands and gravels and generally run toward the flood plain areas. The major channels cutting the eastern plateau of the valley in Sohag area have a general westward direction with small deviation towards the southwest or northwest. The major channels cutting the western plateau have a general eastward trend with some running southeastward and others take the northeast direction. El-Hadad *et al*. (2003) mention that these channels may be formed during late Miocene time but they are evidently pre-dated the deposition of the Pliocene Muneiha sediments. Field observations show that this is the case because Pliocene clays are present near the channels' entrances. Since their beginning, these channels have seen a series of active phases separated by dry inactive ones.

2. Geologic Setting

The geology of the studied area can be summarized as follows:

a. The Nile Valley in the studied area is bounded by the lower Eocene limestone plateaus. Due to variations in the lithology and faunal content, this sequence is divided into two formations; the Thebes Formation at the base and the Drunka Formation at the top.

b. The Thebes Formation (Lower Eocene, was first introduced by Said, 1990) is represented by a thick bedded and laminated limestone succession with flint bands. Lithologically, the lower part of the Thebes Formation is characterized by a medium- to thick bedded, massive yellowish white limestone with abundant Nummulites, Assilines, and Operculines (Mahran *et al*., 2013).

c. The Drunka Formation covers more than 90 % of the area around Sohag. It overlies the Thebes Formation and is easily differentiated from it by its snow white color and massive bedding. The Drunka Formation is composed of a laminated limestone with chert bands interbedded with bioturbated hard massive limestone, including large silicified limestone concretions (up to 1.2 m in diameter). The upper part (up to 100 m) is composed of a grayish white, massive to bedded bioturbated limestone (Mahran *et al*., 2013).

3. Climatic situation in the study area

Sohag area belongs to the arid belt of Egypt. It is characterized by dry climate. The rainfall in the area is variable from time to time during the year with a yearly average ranging between nill in summer to 17 mm in winter; with an average of about 4.1 mm/yr (Table 3). The rainfall in the Sohag area is very irregular and sometimes it happen suddenly with high rate; in this case where the rainfall rate is relatively higher than the infiltration capacity of the soil and evaporation; increases the chance for flood hazardous (Kariem, 2001). The average temperature in the area is about 23.2 degree (Egyptian Meteorological authority, EMA, database 2000). The highest temperature is recorded in August while the minimum is recorded in January (Table 3) with an average of between 14 - 30.8℃. The seasonally average of relative humidity along the area of study is ranging between 45 – 65 % in winter and 25 – 40 % in summer with an average of about 41 % / year (EMA, 2000). Wind is the horizontal movement of air parallel to the earth's surface. Wind speed and direction depend on the forces of the atmospheric pressure gradients and deflection forces related to the rotation of the earth around its axis which depends on the location of the considered area. The area is affected like other places in Egypt by northern winds especially in summer and the mean wind direction is southern to southern east directions. The seasonally average of wind speed rates has somewhat higher rates in spring (3.6 - 5.6 km/hr); intermediate in winter and summer (3-6.3 km/hr) and low rates in autumn (2.3-4.6 km/hr).

Table 3: Summary of the climatic conditions in the study area (EMA)

Area	Average Temp.	Highest Temp.	Lowest Temp.	Average rainfall	Highest rainfall	Average humidity	Average evaporation
Sohag	27 C°	47.3 C°	0.4 C°	4.1 m/yr	17.8 mm	41 %/yr	7.2 mm/yr

4. Hydrologic analysis

Watershed delineation with DEMs is one of the most common methods available for automatically characterizing a watershed, so a watershed analysis on the terrain model for Wadi Dukhan catchment is performed to calculate flow direction, flow accumulation, stream definition, and watershed delineation are shown in Figures (2-12).

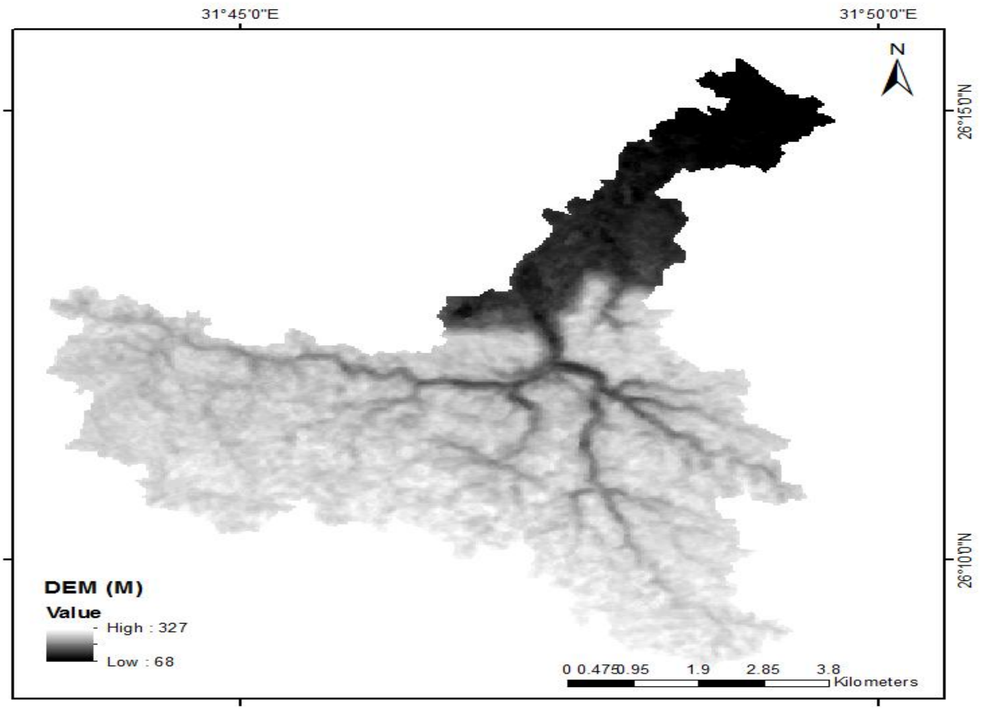


Fig. 2: Map showing a stretched classification of the raw 30 m SRTM DEM of study area which was used in the modeling Procedures

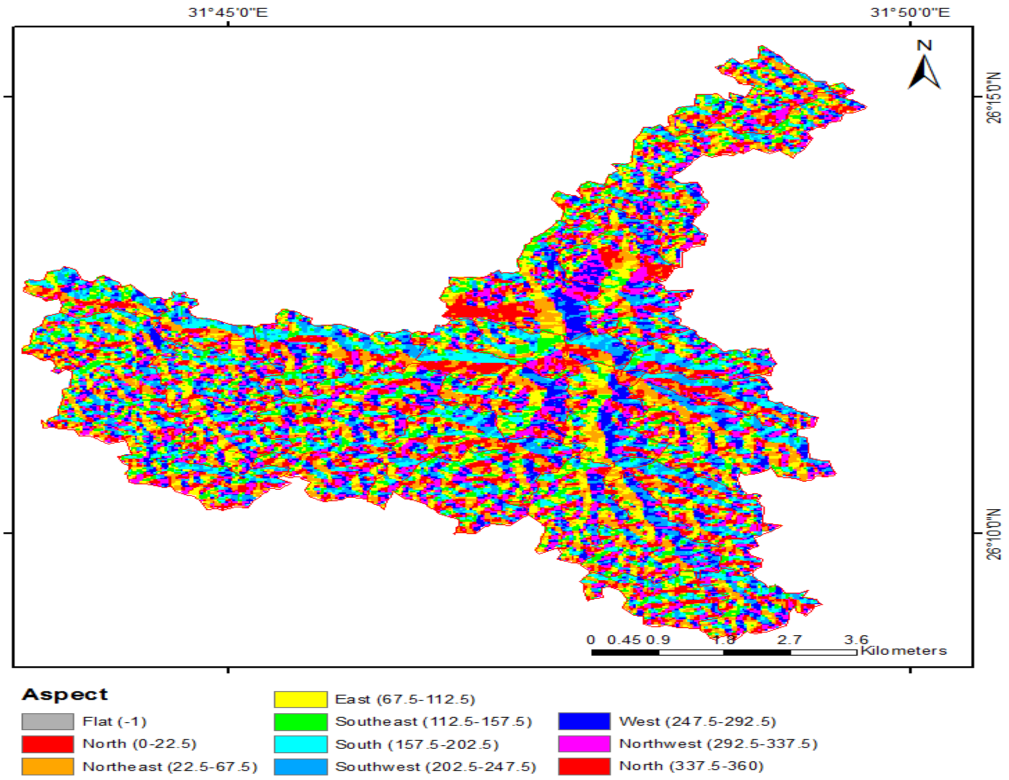


Fig. 3: Map representing the Aspect (the direction of slope) of the study area, directions are represented by colors and translated into degrees in the legend.

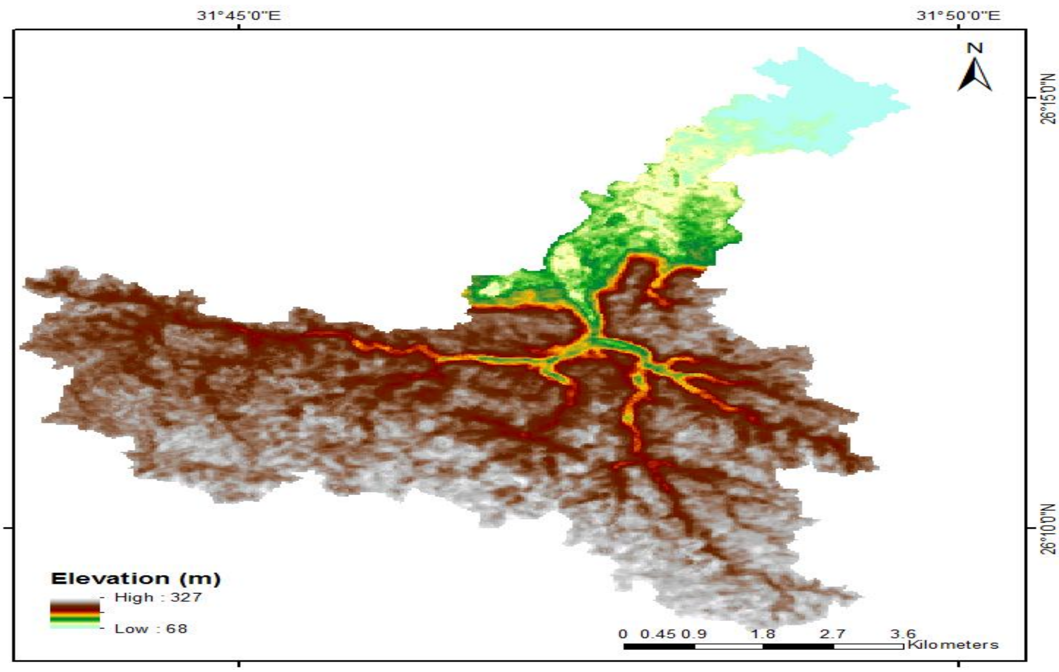


Fig. 4: A classified representation of the DEM elevations of the study area.

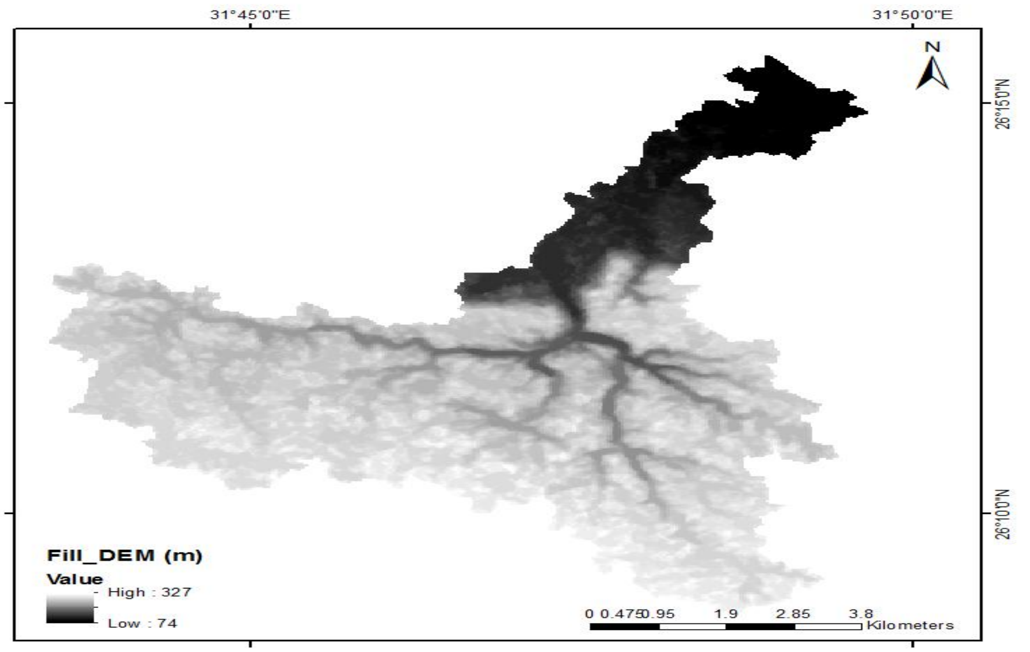


Fig. 5: Map showing the filled DEM of the study area, which is hydrologically corrected.

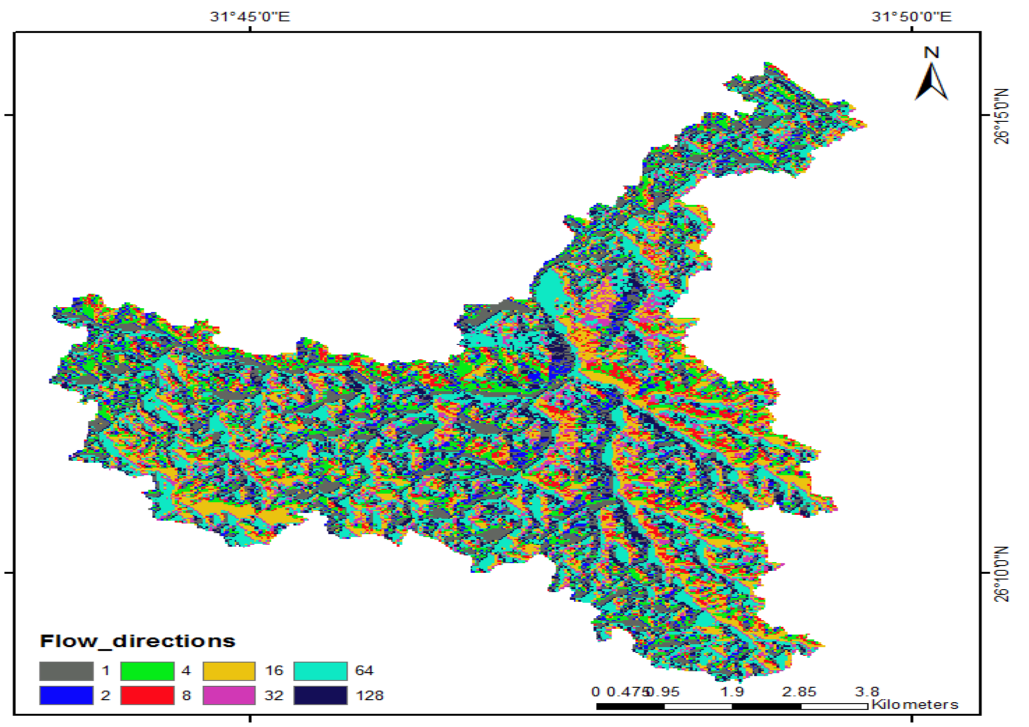


Fig. 6: Visual illustration of the flow direction grid

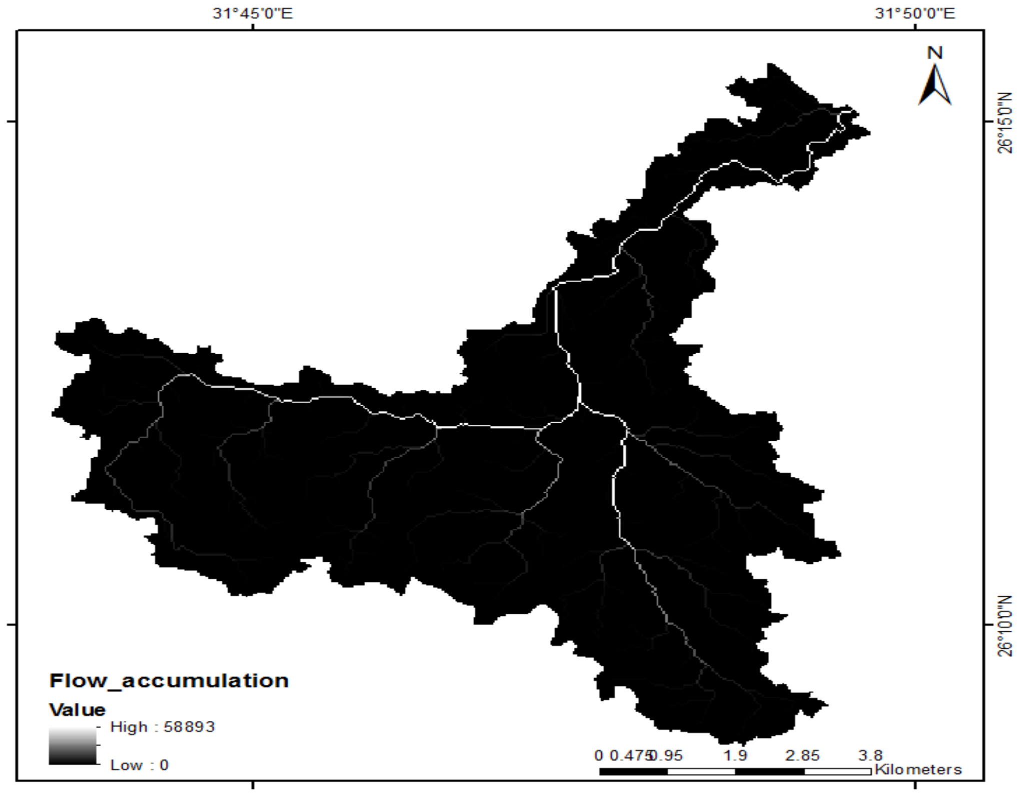


Fig. 7: An illustration showing the assignment of the flow accumulation on the raster of the study area

Fig. 8: Results of Stream definition for study area.

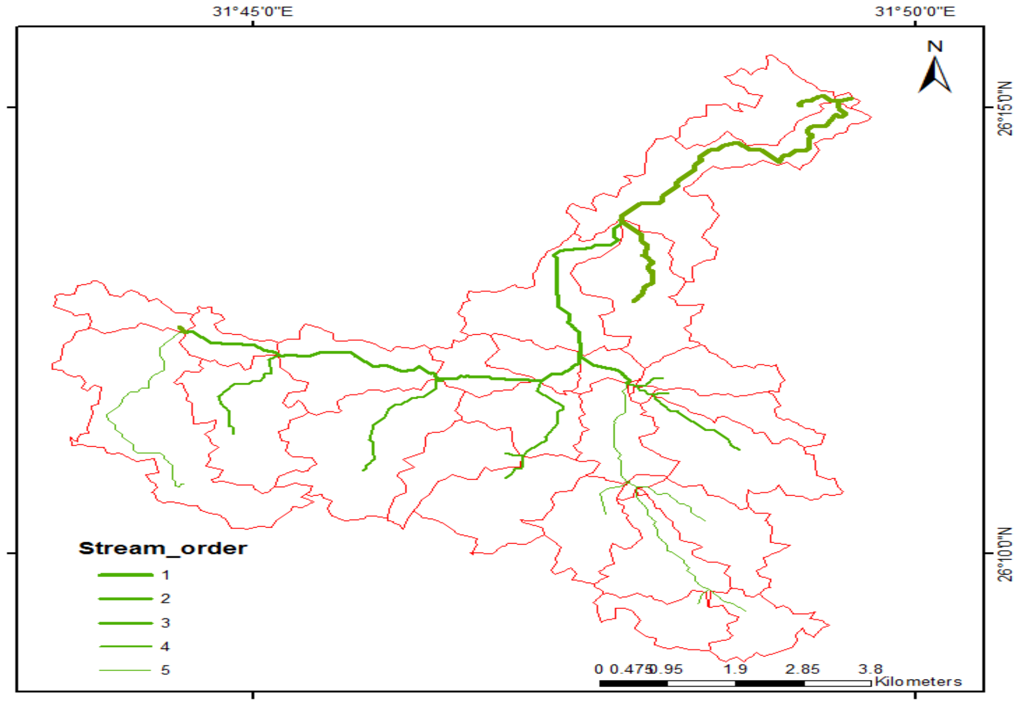


Fig. 9: Map showing the classification of the Stream orders of wadi Dukhan according to Strahler method

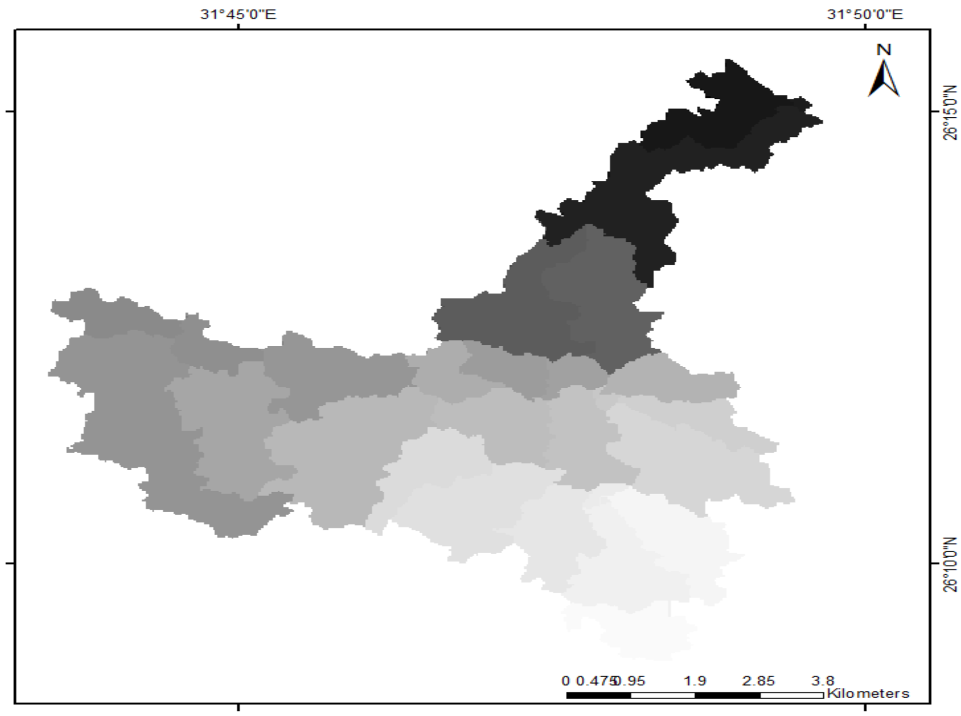


Fig. 10. A raster showing the subcatchments of Wadi Dukhan

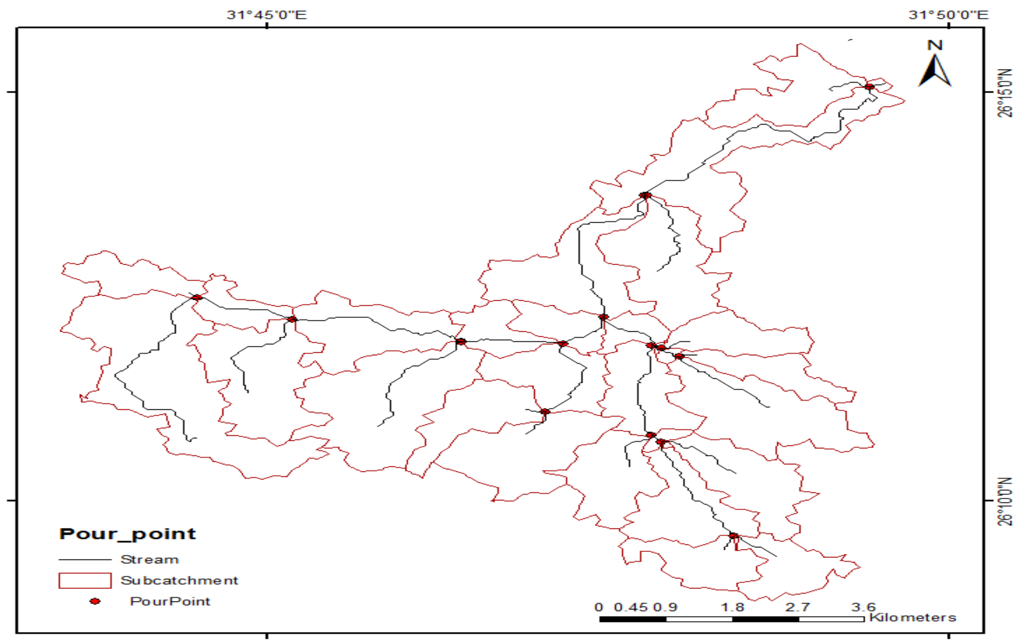


Fig. 11: Pour points within Wadi Dukhan subcatchments.

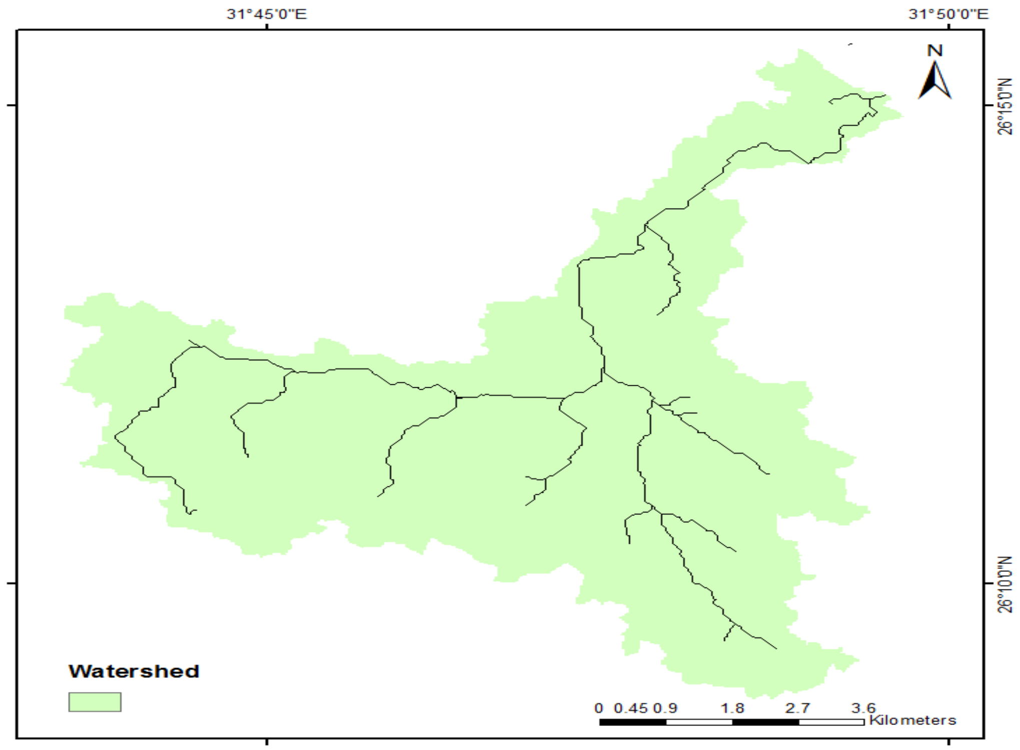


Fig. 12: Watershed of Wadi Dukhan.

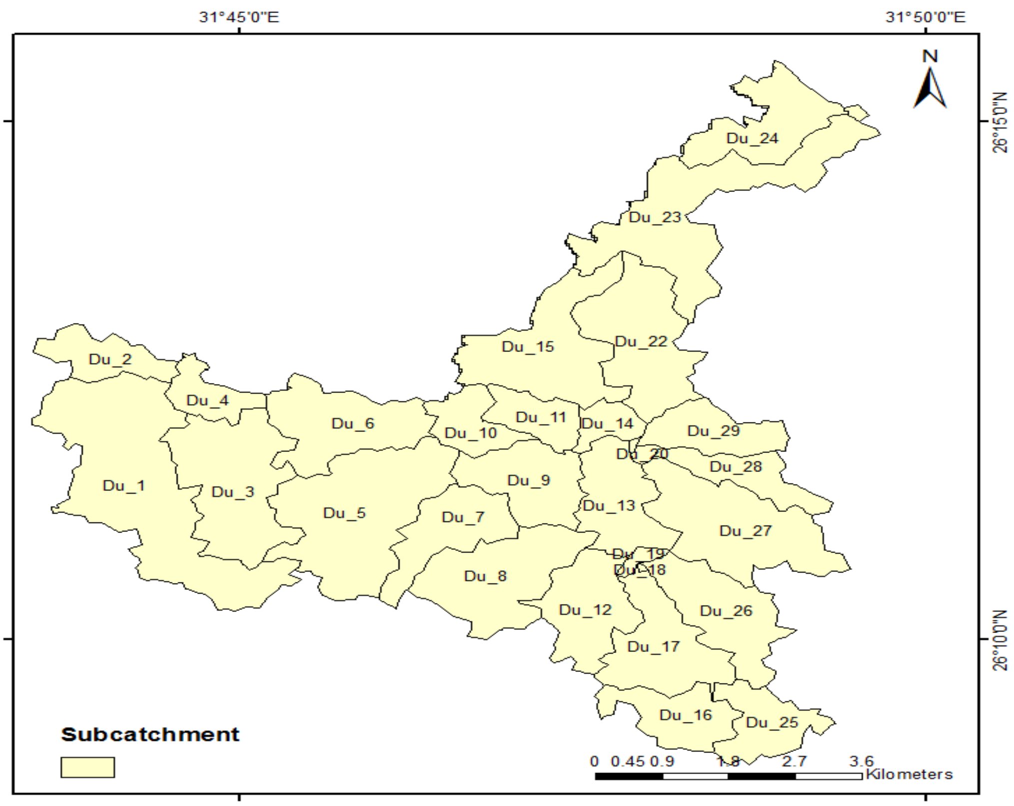


Fig. 13: Subcatchments of Wadi Dukhan

5. Runoff Calculations:

Figure (13) indicated that Wadi Dukhan was divided into 29 subcatchments and the Curve Number for each these Subcatchments was shown in Figure (14).

Fig. 14: Curve Number for each Subcatchments of Wadi Dukhan

The rainfall data used for computation of direct runoff

As shown in Table (4) during the last seven years (2010-2016), it was found that Wadi Dukhan rained six times, three of these events were during 2012, while the rest of the times were once a year. Therefore, 2012 was the wettest year. These rains ranged in intensity and were highest on 4/11/2012 and were 0.9 mm/hour, while the rest of the values ranged from 0.3 - 2 mm/hour.

Table 4. The rainfall data used for computation of direct runoff

Date	Amount of precipitation (mm/hr)
27/10/2016	1.0
25/1/2013	0.4
24/12/2012	0.3
5/12/2012	0.3
4/11/2012	1
17/1/2011	0.9
29/12/2010	0.2

It can be seen from Table (5) that Wadi Dukhan was divided into 29 subcatchments. The present analysis of runoff generation in the SCS model is mainly relied on CN values, which was a function of AMC, slope, soil type and land use. The CN value reflected the runoff potential. Under the same precipitation condition, low CN values mean that the surface has a high potential to retain water. While high values mean that the rainfall can be stored by the land surface only to a small extent. It was found that a very large area of Wadi Dukhan region has a high CN value of 86, which means that the study area is in a poor hydrological condition that makes the water run-off high. This is due to the type of soil and poor vegetation. It was found that the highest value of the runoff was in subcatchment 24 because of the large area and its presence at the exit of the valley despite the flatness of its surface and the type of soil, which absorbs a large amount of water, so this place is at risk of flooding. For subcatchments 1, 2 and 3 the CN value was high, given the large area, but not at risk of flooding due to the elevation of these areas and the presence of hardened limestone, which does not store water. As for subcatchments 13, 9 and 10, an increase in the value of surface run-off was observed, despite their small area, but they are located in the belly of the valley. In the rest of the places, the runoff values were small and distributed over the area, which does not pose a threat to these places.

Table 5. Runoff for each subcatchment (Wadi Dukhan).

Name	Shape Perimeter (km)	Shape Area (km2)	CN	S	I	Q at P=0.4	Q at P=0.3	Q at P=1	Q at P=0.2
Du_1	15.975	5.377	86	41.35	8.27	138.29	195.18	36.31	309.07
Du_2	5.264	1.005	84	48.38	9.68	195.77	273.69	55.92	429.64
Du_3	10.438	2.959	84	48.38	9.68	195.77	273.69	55.92	429.64
Du_4	4.600	0.742	84	48.38	9.68	195.77	273.69	55.92	429.64
Du_5	10.766	3.882	79	67.52	13.50	402.27	554.13	129.34	857.95
Du_6	8.033	2.156	79	67.52	13.50	402.27	554.13	129.34	857.95
Du_7	7.030	1.562	78	71.64	14.33	456.33	627.31	148.98	969.37
Du_8	7.967	2.480	78	71.64	14.33	456.33	627.31	148.98	969.37
Du_9	6.309	1.659	75	84.67	16.93	649.51	888.36	220.00	1366.16
Du_10	4.896	0.889	75	84.67	16.93	649.51	888.36	220.00	1366.16
Du_11	4.344	0.837	75	84.67	16.93	649.51	888.36	220.00	1366.16
Du_12	7.291	1.758	78	71.64	14.33	456.33	627.31	148.98	969.37
Du_13	6.890	1.655	65	136.77	27.35	1761.57	2384.99	639.82	3631.95
Du_14	3.489	0.505	65	136.77	27.35	1761.57	2384.99	639.82	3631.95
Du_15	10.620	2.724	65	136.77	27.35	1761.57	2384.99	639.82	3631.95
Du_16	6.341	1.281	78	71.64	14.33	456.33	627.31	148.98	969.37
Du_17	8.832	1.978	78	71.64	14.33	456.33	627.31	148.98	969.37
Du_18	0.477	0.013	69	114.12	22.82	1211.35	1645.33	430.61	2513.40
Du_19	1.885	0.142	69	114.12	22.82	1211.35	1645.33	430.61	2513.40
Du_20	1.145	0.082	65	136.77	27.35	1761.57	2384.99	639.82	3631.95
Du_21	0.687	0.022	60	169.33	33.87	2732.31	3688.00	1012.48	5599.49
Du_22	8.930	2.590	63	149.17	29.83	2106.37	2848.04	771.78	4331.47
Du_23	16.210	3.617	60	169.33	33.87	2732.31	3688.00	1012.48	5599.49
Du_24	8.575	1.756	60	169.33	33.87	2732.31	3688.00	1012.48	5599.49
Du_25	6.384	1.205	78	71.64	14.33	456.33	627.31	148.98	969.37
Du_26	7.768	1.945	75	84.67	16.93	649.51	888.36	220.00	1366.16
Du_27	9.467	2.921	69	114.12	22.82	1211.35	1645.33	430.61	2513.40
Du_28	6.045	1.008	70	108.86	21.77	1098.30	1493.20	387.91	2283.09
Du_29	5.077	1.173	70	108.86	21.77	1098.30	1493.20	387.91	2283.09

Conclusion

From the results of this study on Wadi Dukhan in the Western Desert in Sohag Governorate, the following points were obtained:

1- This study reflected the usefulness of using GIS technology in estimating the distribution of surface runoff over the watershed.

2- Soil Conservation Service Curve Number method was used to estimate the runoff of Wadi Dukhan. According to the geological assessment of the area it was found that there are two main areas. The first layer is made of hardened limestone, which reduces water intrusion and increases runoff. The hydrological soil group 'C' was chosen for this area, so the corresponding CN was 86. This value increases with increasing slope; it was in some places up to 86. The second category was composed of Quaternary flood sediments, which consist of grains sand and gravel, causing a decrease in runoff rates and an increase in the possibility of water infiltration into groundwater; this class is classified as 'A' hydrologic soil group type. The corresponding CN value was 63. This value also differed according to the slope difference in this region.

3- WadiDukhan was divided into 29 subcatchments. The highest value of runoff was found in subcatchment 24 because of its large area and its existence in the outlet of the valley in spite of flat surface and the type of soil, which is working to absorb a large amount of water, so this place be at risk of flooding. As for subcatchments 23 and 21, their values of runoff were high; since they have the lowest curve number 60. Although subcatchments 1 and 5 have the highest area respectively and they have low run off, because of they have the low curve number (86 and79).

For subcatchments 1, 2 and 3 the CN value was high, given the large area, but not at risk of flooding due to the elevation of these areas and the presence of hardened limestone, which does not store water. As for subcatchments 13, 9 and 10, an increase in the value of surface run-off was observed, despite their small area, but they are located in the belly of the valley. In the rest of the places, the runoff values were small and distributed over the area, which does not pose a threat to these places.

Recommendations

To mitigate and/or prevent a risk from a flash flood event, an organized agenda should be ready before, during and after each possible event. This agenda should involve the social, economic, and the environmental aspects within the target area. Therefore, a research agenda incorporates the various components required to cope with flash floods has to be developed, preferably on nationwide.

The key recommendations for this agenda are:

(1) Greater emphasis on increasing understanding of the social processes involved in flash flood warning, particularly in the response phases.

(2) The need to reduce vulnerability in sustainable ways compatible with long-term economic and social goals. The relationship between hydrometeorology and social science is seen as critical to advancing our abilities to cope with flash floods.

Record and monitoring system have to be established on a regular raster distribution nationwide, regardless of the spatial frequency of the flash flood events, only this way reliable forecasting model that can be applied. A flash flood warning system is mandatory to minimize the risk of a flash flood event. The warning value is attributed to the lead time of the basin. In addition, warnings indicating magnitude of the threat and designing specific regions within county warning areas are more useful.

Evaluation statistics such as probability of detection and false alarm ratio should be stratified by the scale of events. This has to be attached to the establishment of a reliable database of events for the verification purposes involving the well-recognized difficulties and data gaps.

Sustainable and long-term mitigation policies, Economic development and hazard management are not mutually exclusive, though they are frequently seen as such. Mitigation efforts will only be successful if they work with, rather than against, community goals and priorities. Economic growth is not sustainable if it is devastated by a flash flood event. Proper infrastructure, such as dams, have to be constructed on the suggested streams, upstream of the given high discharge outlets, to protect the public and private properties.

Public awareness is important to give the local community access to information on problems which directly involve them, and to work out evaluation procedures for the prepared estimates and plans.

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تقييم مخاطر الفيضانات باستخدام نظم المعلومات الجغرافية بوادي الدخان ، الصحراء الغربية ، محافظة سوهاج، مصر

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المستخلص

تهدف الدراسة الحاية إلى التعرف على وادي دخان بالصحراء الغربية بمحافظة سوهاج والذي تبلغ مساحته 50 كيلومترًا مربعًا من حيث طبيعته وهطول الأمطار عليه ، وذلك للتحديد الأماكن المعرضة لخطر الفيضانات. استخدمت هذه الدراسة طريقة رقم المنحنى الشبكي (CN) من خلال تحليل الصرف GIS الذي يعمل على نماذج الارتفاع الرقمية (DEM) لتقدير عمق الجريان السطحي في مستجمعات وادي الدخان ، سوهاج ، مصر. في نظام النمذجة الهيدرولوجية القائمة على SCS (خدمة حفظ التربة) ، حيث يلعب CN دورًا مهمًا في تحديد الجريان السطحي. يأخذ في الاعتبار عوامل مثل المنحدر والغطاء النباتي ومنطقة مستجمعات المياه. تم تعيين قيم رقم المنحنى من الجداول القياسية NRCS لمجموعات التربة المائية المتقاطعة وخرائط استخدام الأراضي لإنشاء خريطة قيم CN. تم تحديد تأثير الانحدار على قيم CN وعمق الجريان السطحي. تم استخدام بيانات الخرائط الطبوغرافية وخرائط استخدام التربة والأراضي في المعالجة المسبقة في Arc GIS 9.3 و Arc Hydro 9 لحساب المعلمات الهيدرولوجية. لتقدير رقم المنحنى الذي تم من خلاله تقريب الجريان السطحي اليومي ، تم استخدام برنامج GIS لتوليد البيانات وتخزينها ومعالجتها وتكاملها. تم إجراء الحسابات لحجم التخزين السطحي والسحب الأولي.

وتبين أنه خلال السنوات الست الماضية (2010-2016) أمطرت وادي دخان ست مرات ، ثلاث منها كانت خلال عام 2012 ، بينما كانت بقية الأوقات مرة واحدة في السنة. كان هطول الأمطار في عام 2012 هو الأعلى (1 ملم / ساعة). وبحسب التقييم الجيولوجي للمنطقة فقد وجد أن هناك منطقتين رئيسيتين. الأول مصنوع من الحجر الجيري المتصلب ، مما يقلل من تسرب المياه ويزيد الجريان السطحي. تم اختيار مجموعة التربة الهيدرولوجية "C" لهذه المنطقة ، وبالتالي فإن قيمةCN المقابلة لها تساوي 86. وتزداد هذه القيمة مع زيادة الانحدار ؛ كان في بعض الأماكن يصل إلى 86. وتألفت الفئة الثانية من رواسب الفيضانات الرباعية ، والتي تتكون من حبيبات الرمل والحصى ، مما تسبب في انخفاض معدلات الجريان السطحي وزيادة في إمكانية تسرب المياه إلى المياه الجوفية. تصنف هذه الفئة على أنها نوع مجموعة التربة المائية "أ". كانت قيمة CN المقابلة 63. اختلفت هذه القيمة أيضًا وفقًا لاختلاف الميل في هذه المنطقة. أيضا ، في الدراسة الحالية تم تقسيم وادي دخان إلى 29 مستجمعا فرعيا. وجد أن مساحة كبيرة جدًا من المنطقة بها قيمة CNعالية تبلغ 86 ، مما يعني أن منطقة الدراسة في حالة هيدرولوجية سيئة تجعل جريان المياه مرتفعًا. ويرجع ذلك إلى نوع التربة وسوء الغطاء النباتي.